

“HYDROGEN FUEL”

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Why Hydrogen Fuel ?

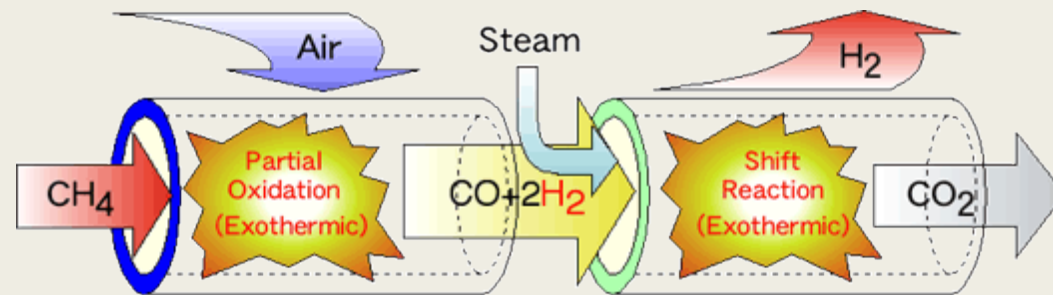
- Hydrogen is a zero emission fuel and hence it will not affect the atmosphere.
- Hydrogen fuel unlike conventional fuels produce far more energy.
- Hydrogen fuel is the clean and easily accessible fuel.
- The main benefit of using hydrogen fuel is that it is renewable.

Production

- There are a number of ways to produce hydrogen –
 - Steam Reforming From Natural Gas
 - Electrolysis
 - High-Temperature Water Splitting
 - Photobiological Water Splitting
 - Photoelectrochemical Water Splitting

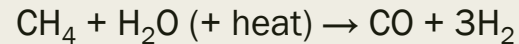
Production: Steam Reforming From Natural Gas

- Natural gas contains methane (CH_4) that can be used to produce hydrogen with thermal processes, such as steam-methane reformation and partial oxidation.
- In steam-methane reforming, methane reacts with steam under 3–25 bar pressure in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide.

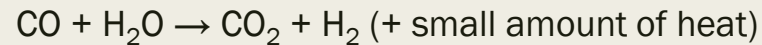


Production: Steam Reforming From Natural Gas

- Steam-methane reforming reaction



- Water-gas shift reaction

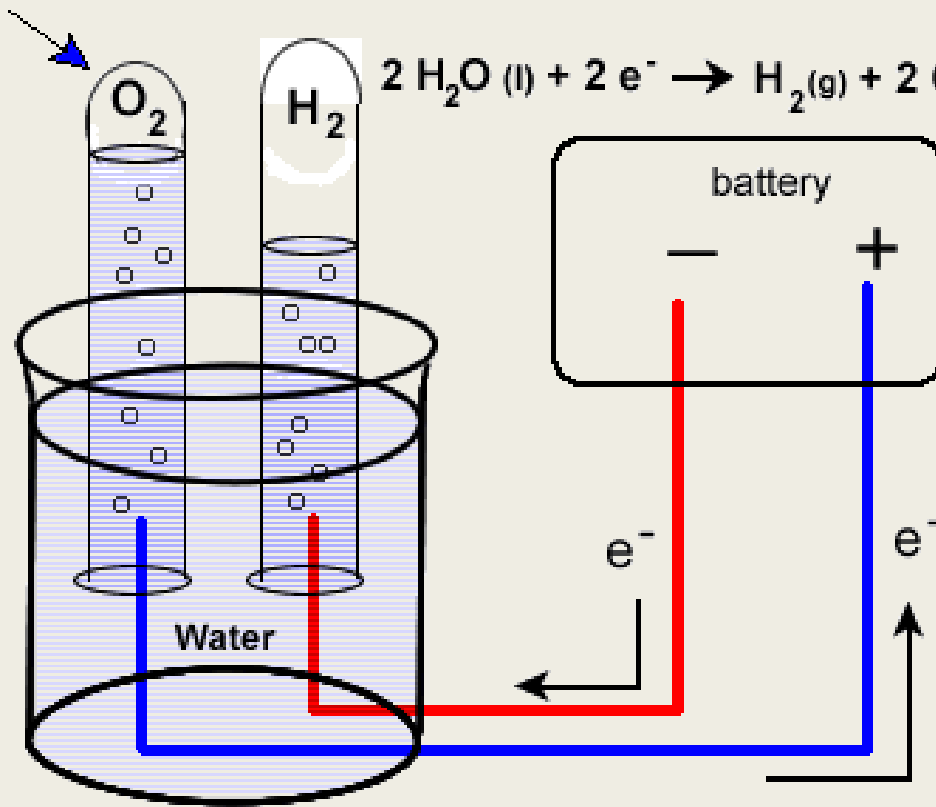
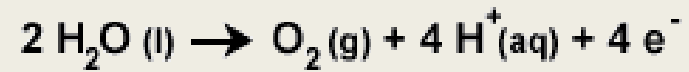


- Subsequently, in what is called the "water-gas shift reaction," the carbon monoxide and steam are reacted using a catalyst to produce carbon dioxide and more hydrogen.
- In a final process step called "pressure-swing adsorption," carbon dioxide and other impurities are removed from the gas stream, leaving essentially pure hydrogen.

Production: Electrolysis

- Electrolysis, process by which electric current is passed through a substance to effect a chemical change.
- The chemical change is one in which the substance loses or gains an electron (oxidation or reduction).
- The process is carried out in an electrolytic cell ,
- Electrolytic cell is an apparatus consisting of positive and negative electrodes held apart and dipped into a solution containing positively and negatively charged ions.

Production: Electrolysis



Production:

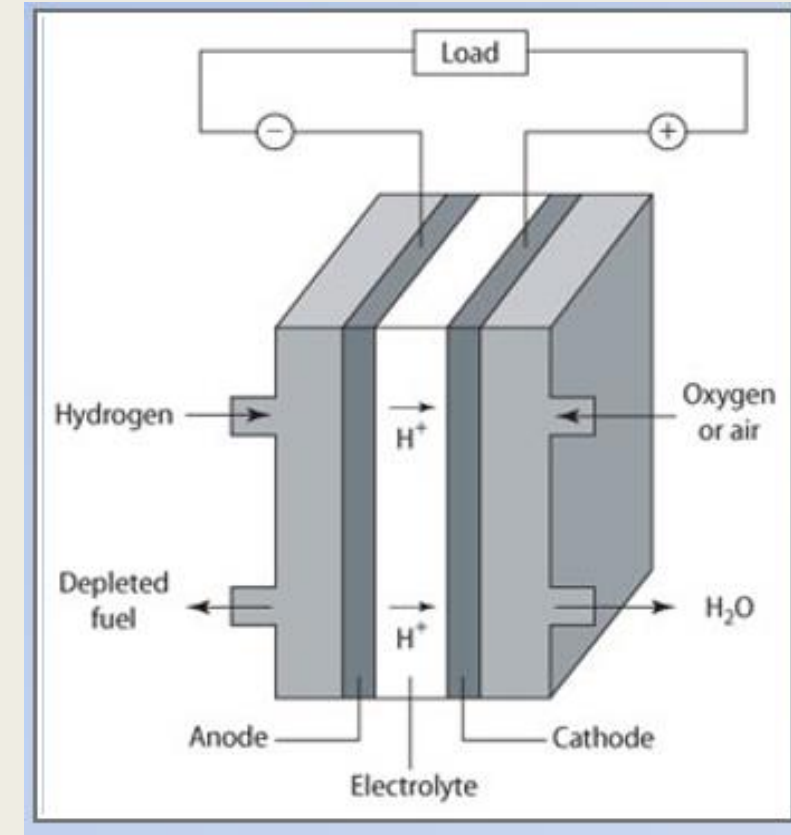
Method	Process	Implementation
Steam reforming of methane gas	<p>In presence of nickel catalyst & at 700 – 1100 °C:</p> $\text{CH}_{4(g)} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_{(g)} + 3\text{H}_{2(g)}$ <p>Next reaction at lower temperature:</p> $\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_{2(g)} + \text{H}_{2(g)}$	Current major source of hydrogen
Hydrogen from coal (Gasification)	<p>At high temperature and pressure:</p> $\text{Coal} + \text{H}_2\text{O}_{(g)} + \text{O}_{2(g)} \rightarrow \text{syngas}$ $\text{Syngas} = \text{H}_2 + \text{CO} + \text{CO}_2 + \text{CH}_4$	Current method of mass hydrogen production
Electrolysis of water	<p>Electric current passed through water:</p> $2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{H}_{2(g)} + \text{O}_{2(g)}$	Not in widespread use due to cost of electricity
Solar – Hydrogen system	<p>Electric current passed through water:</p> $2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{H}_{2(g)} + \text{O}_{2(g)}$	Not in widespread use due to cost of renewable energy sources

Working of Fuel Cell

- A fuel cell consists of two electrodes sandwiched around an electrolyte.
- Oxygen passes over one electrode and hydrogen over the other.
- Spurred by a catalyst, hydrogen oxidises into hydrogen protons and give up its electrons to the electrode, which thereby becomes the anode.
- This build up of negative charge then follows the path of least resistance via the external circuit to the cathode.

Working of Fuel Cell

- Flow of electrons through a circuit produces the electricity.
- As the electrical current begins to flow, hydrogen protons pass through the membrane from anode to the cathode, react with oxygen at the cathode to form water, heat and electricity produces.
- Anode Reaction : $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
- Cathode Reaction: $\frac{1}{2} \text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O} + \text{Energy}$



Uses

- It can be used in electrochemical cells or internal combustion engines to power vehicles and electric devices.
- It is used as a fuel for the propulsion of spacecraft.
- In the future, hydrogen could also join electricity as an important energy carrier.
- Hydrogen fuel can be used in both mobile fuel cells and stationary fuel cells.
- Mobile fuel cells includes the transportation industry such as cars, trucks and buses.
- Stationary fuel cells can be used in power plants, businesses, homes and even cell phones and laptop computers.

Advantages:

- **Carbon-emission free:** These fuel cells do not emit harmful carbon emissions in the air that cause pollution and affect global warming.
- **Accessible and clean:** One of the advantages of using hydrogen as an energy source is its being readily available. Moreover, the end-result is a clean and powerful source of energy.
- **Renewable energy source:** Hydrogen is the most abundant element in the universe. Consequently, it becomes one of the renewable sources of energy.

Advantages:

- **Fuel efficiency:** Due to the fact that hydrogen is capable of producing more energy per pound of fuel as compared to gas and diesel, it becomes more fuel efficient.
- Hydrogen produces far more heat energy than other fuels.

Disadvantages:

- **Nitrogen Dioxide Emission:** Nitrogen dioxide is a toxic gas and can still be harmful when ingested by humans.
- **Storage Issues:** This element is also a challenge to move and transport. Compared to oil which can be channeled through pipelines and coal which can be moved to one location to another using trucks, transporting hydrogen can be expensive and hence storage.
- **High Cost:** Aside from having to spend a lot of money to transport hydrogen, the time it takes to break down its elements makes the process expensive as well.
- **Highly Flammable**

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THANK YOU

